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**MEMOIR 107**

No. 96, GEOLOGICAL SERIES

# Road Materials in the Vicinity of Regina, Saskatchewan

BY

**L. Reinecke**

OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1919

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# Road Materials in the Vicinity of Regina, Saskatchewan.

## CHAPTER I.

## INTRODUCTION.

A survey for road materials was made in the vicinity of the city of Regina, Saskatchewan, during the summer of 1917. The area covered is about 50 miles wide east and west and 25 miles north and south, with Regina lying nearly in the middle. Early in the season a short trip was made to Estevan, 115 miles southeast of Regina, where a number of outcrops of burnt and partly vitrified clay beds used for road material were examined. As the traffic near Regina is probably the heaviest on any country roads in Saskatchewan, and road materials are exceptionally scarce within wagon hauling distance of the city, it was thought that work in that area would probably be of more immediate value to road builders than if undertaken in other parts of the province.

The areas immediately adjacent to railway lines going into Regina were closely prospected for road materials for distances of about 25 miles from the city and in some cases farther out. The country between the railways was not in all cases examined with the same care.

### *Topography and Geology.*

The district in the vicinity of Regina is on the whole an extremely flat, treeless prairie. Northeast of the city about 10 to 15 miles is the margin of a belt of country characterized by small hillocks and ridges rising from 10 to 50 feet over this flat plain, and still farther northeast by many small ponds and thick clumps of brush and low trees. The southwestern edges of this belt trend roughly northwest by north passing near Kathrinthal and Pilot Butte. There are a number of small hills also near Condie and in the northwestern part of the area. The district is drained by the Qu'Appelle river and its tributaries. The Qu'Appelle flows east-west on the north side of and across part of the area. The river lies in a steep-sided, flat-bottomed trough about a mile wide and 2[illegible] feet deep and its tributaries enter this trough from the south through deep, steep-sided gorges which extend back 15 miles from the main river in places. On the slopes of the Qu'Appelle valley and its deeper tributary gorges are many small, dome-shaped hills and short-steep-sided glacial ridges.

The surface of the area is covered for the most part by heavy clay carrying a small proportion of stone and boulders. In the hilly sections and along the edges of the deeper valleys there are deposits of gravel, sand, and silt occurring in connexion with deposits of stony clay. The stony clay is believed to have been deposited in the glacial period by sheets of melting ice; the gravels were evidently laid down by streams connected with the ice-sheets or in lakes formed directly or indirectly through glacial agencies.

No outcrops of extensive, bedded sediments were seen in this area although outcrops of Cretaceous shales are described on the west side of

Lost Mountain lake just to the north.[1] Excavations made in the unconsolidated clays and gravels that lie on the surface reveal conditions that are very similar in most places. For from 4 to 9 inches from the surface there is a layer of black or brown soil discoloured by organic material and comparatively loose in texture. Below this is a belt from 1 to 2 feet thick in which the unconsolidated drift has been cemented together by a white crust—presumably largely of lime carbonate and alkali salts—into a much firmer and harder mass. In clays the lower part of the cemented belt is rarely 3 feet from the surface. In open-textured gravels some of the white crust was observed at 9 feet from the surface and a coating of iron oxide down as far as the gravel had been excavated. The permanent groundwater-level, just below which the ground is saturated with water, is, if present, in most places many feet from the surface.

### *Road Conditions.*

Roads in this district follow section lines, that is they run east-west or north-south in practically all cases and their grades are on the average very low. Nearly all the country roads are unsurfaced, parts of them are ungraded "prairie trails." In the comparatively dry summer of 1917 from 50 to 75 per cent of the roads were in excellent condition, some of the best stretches being the prairie trails. After a day's rain the clay roads dried quickly and in most places the surface broke up into a crumbly mass so that deep ruts formed in the wet clay soon disappeared. Along stretches where the roads crossed undrained sloughs their surfaces were generally rough. Where the underlying soil was of gravel or even of sand the road surfaces were in most places firm and traction easy, but where the subsoil was of fine sand heavy traffic formed holes of loose sand. Although the clay roads, especially those carrying heavy traffic, are undoubtedly in bad shape after long periods of wet weather, the surfaces of the earth roads are in good condition for many more days in the year than they are in eastern Canada.

The comparatively satisfactory condition of the earth roads is due in a large measure to the climate, to the character of soils and subsoils, and to the position and movements of groundwater through the soils and subsoils. The depth of groundwater-level combined with a dry atmosphere tends to quick drying of the surface soil after a rainstorm. With the low annual precipitation this produces a firm surface on clay roads for more days in the year than where such conditions do not hold. The crumbling of the clay surfaces is probably due to the action of lime in the soil, which breaks up the soil in drying and tends to prevent the forming of hard ridges along the wheel tracks. The belt of cemented subsoil acts as a firm foundation both in clay and sand roads under conditions of light traffic. In slough areas, however, the ground is saturated with water close to the surface and this dry coherent foundation is absent. This is probably also true of the bottoms of wide valleys like the Qu'Appelle. Under heavy traffic, also, water penetrates deeper into the clay surfaces during wet periods and the crumbling of the clay upon drying is not so noticeable, so that the roads are either soft or rough for long periods. It is principally, then, along heavily trafficked roads and across wet places that the surfacing of the roads becomes necessary.

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[1] Ries, H., and Keele, J., "Report on the clay and shale deposits of the western provinces," pt. II, Geol. Surv., Can., Mem. 25, 1913, p. 26.

# ROAD MATERIALS.

The only materials available for road surfacing in this district are glacial boulders, gravels, and sands. The burnt clays of Estevan lie southeast of the mapped area.

## GLACIAL BOULDERS.

The supply of boulders is very small and they are not present in sufficient quantity at any place to form an effective road surface by themselves. The largest quantity was found along the northern edge of the Qu'Appelle valley west of Lumsden, where from 1,200 to 1,500 cubic yards of piled boulders were seen in an area of about three half sections south of the township line road. If the same amount could be obtained from the corresponding half sections to the north of the township line road, there would be just sufficient stone to surface 1½ miles of road with crushed stone 16 feet wide and 6 inches thick (after rolling). In other places, 200 cubic yards have been seen in one half section; but over the greater part of the area there is no stone at all. Field stone has been shipped from Lumsden, Craik, and Davidson and sold in Regina at $9 per cord uncrushed. Twelve hundred cords were shipped to Regina in 1911 from Findlater and brought $11.65 per cord f.o.b. cars Regina (uncrushed). The stone after crushing is used in filters and in connexion with the disposal of sewage.

## BURNT CLAY.

Natural burnt clay deposits occur at Estevan 115 miles southeast of Regina. They lie adjacent to beds of ash that evidently are the remains of beds of coal which were set on fire at some time in the past and had burnt the nearby clays to the consistency of ordinary building brick. The burnt clay is traversed by numerous closely spaced cracks and upon excavation it breaks up easily into fragments from 1 to 4 inches across. A part of the road leading south out of Estevan was surfaced with this material for a distance of half a mile in August 1915. The clay fragments were dumped and spread to about the width of the wheels and to a thickness of from 6 to 9 inches. After a few months of service the clay had ground to dust in the wheel tracks and had not cemented in other parts of the road. Lignite cinders and ashes were then placed over the clay, about the same amount being used as in the case of the clay, and the surface was dragged. The cinders cemented the mass together almost at once and the ensuing surface was satisfactory. The road carries about 120 vehicles per day in the spring and autumn, of which a large proportion are coal wagons and over one-half are automobiles.

The burnt clay alone is not very durable and has no cementing value. Mixed in the surface of a clay road it would be bound together by the raw clay and would reduce the plasticity of that material, making it harder and less sticky when wet. Sand also diminishes the plasticity if added to a clay road surface, and is more durable than the burnt clay. Sand clay roads have given very satisfactory service under moderately heavy traffic and can be built at low cost if the sand deposits are nearby. At Estevan the hauling and spreading of the burnt clay to a depth of from 6 to 9 inches cost about 50 cents per square yard of surface. Here the deposits were ready burnt and lay near the road. The cost of burning enough raw clay to make a surface thick enough to support traffic near Regina would be very great. If the cost of sand or gravel delivered at the road is as great it would be better economy to use sand or gravel.

## GRAVEL DEPOSITS.

### *General Character.*

*Definition.* Natural deposits of unconsolidated mineral particles grading in size from 3 inches downward are in general called "gravel deposits" in this report. In the area examined the greatest proportion of them are made up of grains over 0.01 inch in diameter. When such gravel is divided by screening into lots containing particles of different sizes, however, only the material over ¼ inch can strictly be called "gravel" and that portion with grains under ¼ inch is spoken of as "sand." Fine sands occurring with the gravel deposits, but apparently in many cases as distinct beds or masses, are for convenience referred to as "silts" in this report. Only about 80 per cent of these silts are made up of grains smaller in diameter than 0.01 inch, and "silt" is not, therefore, the technically correct term to apply to them.

*Location.* The main deposits of gravel lie in a belt trending west of north from near Kronau through Pilot Butte, Condie, and Lumsden, to Findlater. West of Lumsden there is a sheet of gravel at Disley and to the southwest near Rocky lake are other large deposits. All of these except the Findlater gravels are shown on the large map. Small gravel areas are found to the northeast of this belt but the southwestern part of the mapped area is practically without gravel. The Findlater area, 4 miles northwest of Regina, is shown in Figure 3. A sample from Estevan, 115 miles southeast of Regina, was also tested.

*Occurrence and Form.* The larger gravel areas at Findlater, Rocky lake, Lumsden, Pilot Butte, and elsewhere have the form of elongated sheets lying on fairly flat floors of boulder clay. They vary in length from a few hundred yards to over 2 miles, but are very narrow in proportion, and range in depth from 8 to about 25 feet in most places; in one place sand and gravel extended to at least 50 feet from the surface. On the edges and toward the ends of these sheets the deposits become in many places irregular in form, masses of boulder clay projecting upward into the gravel and pockets of gravel lying in the adjacent boulder clay, some of them detached from the main sheet. Such conditions can be observed at the east end of the old pit, No. 18, at Disley, in the large pit at Lumsden, and elsewhere.

The surfaces of the large sheets of gravel are rather flat, and somewhat rounded depressions without outlet, "sags," are a common feature. Below these "sags" the gravel sheet is either covered by several feet of brown sand, silt, or clay, or it does not exist (Figure 2 and Plates I and II). Since the gravel almost invariably lies at the surface on the higher ground, this structural peculiarity should be kept in mind when new deposits are being opened up. The gravels, and the silts lying over them, are well stratified and commonly crossbedded.

Besides the large flat sheets there are numerous small gravel deposits lying in hills of boulder clay. These vary in size from a few cubic yards upward, but are invariably small. The gravel may be exposed at the surface and flanks and simply rest on boulder clay, or it may be partly overlapped by, and in many cases completely covered and surrounded by clay. Deposits of this kind are seen on the banks of Waskana and other creeks where the erosion of the creek valley has exposed one of their flanks. The smaller deposits are nearly always distinctly stratified, the beds are in many cases lens-shaped, and crossbedding is common.

*Texture.* By the texture of a gravel and sand is meant the proportions of the grains of different sizes present in the sample. Texture is probably the most important factor in determining the use to which a sand or gravel can be put in concrete or bituminous work. The significance of the tables showing the texture of the various deposits should, therefore, be understood and they are explained below. The results of laboratory tests on seventeen samples of gravel and sand aggregate are given in Tables I and II. Numerous field tests were made and the results given in Table VI.

An examination of Table VI together with Figure 2 shows that in the large gravel sheets like those at Pilot Butte, Lumsden, and elsewhere, the gravel and sand aggregates contain a small percentage of gravel over ¼ inch, combined with coarse sand. Lying on top of these and easily distinguished from them are small quantities of much finer silts and clays. In the smaller deposits the textures vary sharply and in one pit face the material may change from fine silt or clay to coarse gravel within the space of 10 feet horizontally or a few feet vertically.

*Explanation of Tables.* In the laboratory a sample of the aggregate was first separated on the ¼-inch screen into " gravel " and " sand," sand being the material passing through the screen. Gravel was further separated on a set of standard screens into the sizes indicated in Table I. The sand was separated by a set of Tyler sieves of 8 mesh, 14 mesh, 28 mesh, 48 mesh, 100 mesh, and 200 mesh. The length of one side of each of the square openings in these sieves is indicated in Figure 1.

In this set of sieves the size of the opening in any one sieve is larger than the next smaller one by a definite proportion, that is the area of the opening in the 8 mesh is nearly 4 times that of the 14 mesh, the 14 mesh is four times larger than the 28 mesh and so forth. If, therefore, a sand is separated on these sieves the average volume of the individual grains in one lot is nearly four times that of the average volume of the individual grains in the lot retained on the next smaller mesh. The proportion of the openings in the ¼-inch to the 8 mesh is somewhat higher, but can be determined from the diagram. The results of analyses on these screens, therefore, form a more logical basis for comparing the textures of gravels than the results obtained from the standard series of sieves in which there is no definite proportion between the size of the openings, see Figure 1. The results can be converted from the Tyler system to the Standard by plotting the " cumulative, or total, percentages retained " on a diagram like Figure 1 and reading off the points upon which the curve crosses the ordinates of the various standard sieves.

In Tables I and II the results of laboratory analyses are expressed in cumulative percentages retained on each of the sieves rather than as percentages passing one sieve and retained on the next lower. Results expressed in this way can be more readily used when comparisons are made between one sand and another.

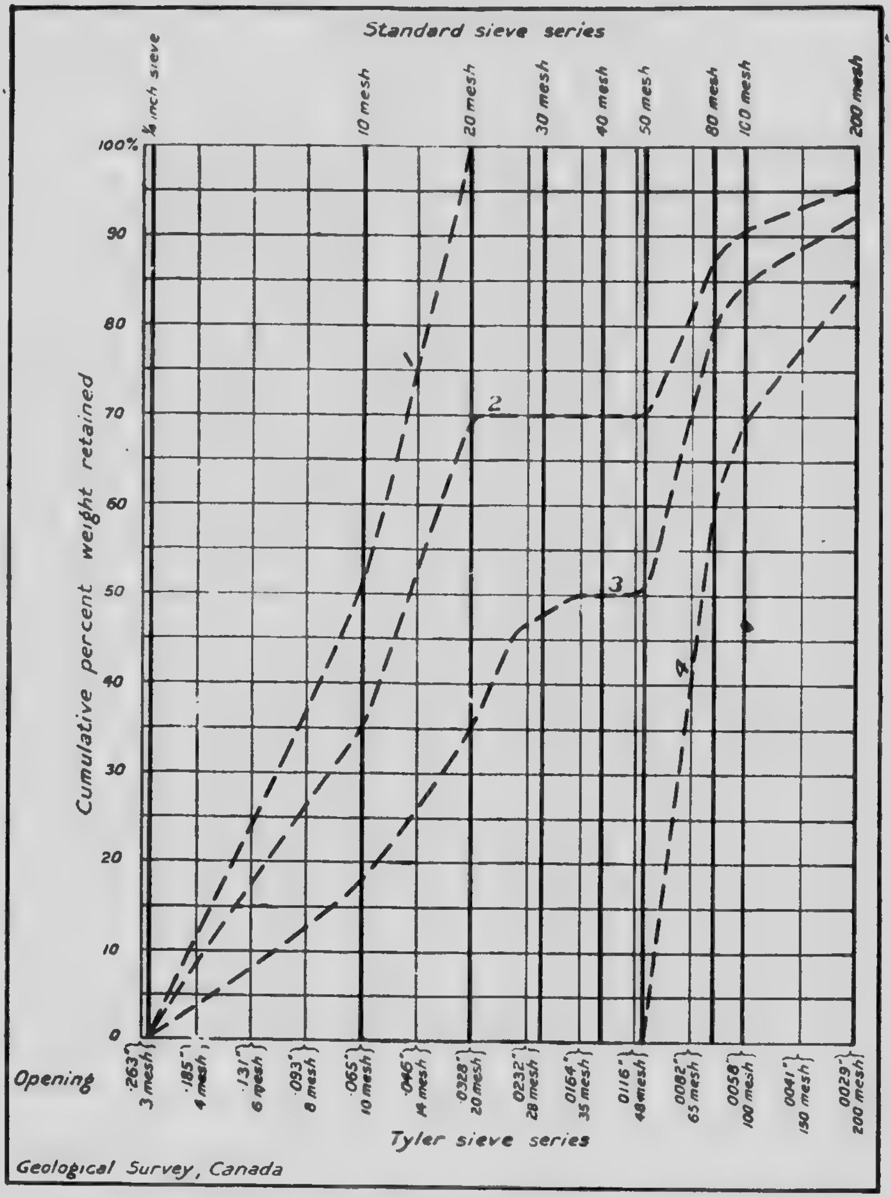

Figure 1. Diagram showing the relation between the texture (grading) of sand and the compressive strength of Portland cement mortar made from it (based on results of experiments by F. H. Jackson, jun., Office of Public Roads, Washington, D.C.). Curves 1 and 4 represent the limiting textures tested by Jackson, and evenly distributed within this zone lie the other 58 combinations. Curve 2 represents the texture of sand with maximum compressive strength. Sands lying between Curves 1 and 3 have compressive strengths from 60 to 100 per cent of the maximum.

In the field tests fewer screens were used and the proportions were determined roughly by volumetric means. Duplicate samples were, however, taken at thirteen localities and tested both in the laboratory and the field. The results showed that the average "cumulative percentages retained" on the screens as obtained from field analyses lay within 5 per cent of the results obtained in the laboratory, except for one screen where the field analyses were 11 per cent too high. The field analyses in Table VI have been corrected by the amount of their average deviation to conform to the laboratory results.

The texture of sands may be conveniently compared by plotting them in a diagram such as Figure 1 where the ordinates represent cumulative percentages retained on each screen and the abscissa represent the screens, diminishing in size to the right. The curve of a coarse sand in this diagram will rise steeply and lie to the left of the finer sands. As will be shown further, page 13, a relation has been drawn between the position of a sand on this diagram and the strength of a Portland cement mortar made from it. Another means of comparing the textures is by a "fineness factor" found by adding the cumulative percentages retained on the set of screens used. In this report the "fineness factor" is equal to the "cumulative percentages retained" on the 8, 14, 28, and 48 meshes. Most of the sands analysed have a fineness factor ranging from 150 to 300 and 150 may be considered as representative of medium and 300 of coarse sand; sands below 100 may be considered fine. The silts lying over the sands and gravels, and in some places within them, have fineness factors lower than 50.

*Table I.—Results of Laboratory Analyses of Textures of Gravel and Sand Aggregates.*

| Map No. | Cumulative percentages retained on screens with openings of diameter in inches | | | | | | Sand passing |
|---|---|---|---|---|---|---|---|
| | 2 | 1½ | 1 | ¾ | ½ | ¼ | ¼ |
| 1 | 1 | 4 | 7 | 10 | 15 | 31 | 69 |
| 8 | 0 | 2 | 5 | 8 | 12 | 19 | 81 |
| 10 | 0 | 1 | 5 | 10 | 21 | 41 | 59 |
| 17 | 0 | 1 | 2 | 4 | 9 | 20 | 80 |
| 20 | 1 | 1 | 5 | 6 | 10 | 20 | 80 |
| 23 | 1 | 4 | 8 | 12 | 19 | 34 | 66 |
| 44a | 0 | 1 | 3 | 4 | 6 | 10 | 90 |
| 44b | 1 | 3 | 7 | 9 | 11 | 16 | 84 |
| 45a | 7 | 21 | 35 | 44 | 55 | 66 | 34 |
| 45e | .. | .. | .. | .. | .. | 0 | 100 |
| 45h | 2 | 3 | 5 | 6 | 8 | 13 | 87 |
| 47 | 3 | 9 | 13 | 17 | [illegible] | 38 | 62 |
| 48 | 2 | 3 | 5 | 8 | 12 | 22 | 78 |
| 58 | 1 | 3 | 8 | 11 | 18 | 31 | [illegible] |
| 63 | 0 | 1 | 2 | 4 | 8 | 19 | |
| 67 | 1 | 2 | 6 | 7 | 10 | 19 | |
| 100[1] | 1 | 3 | 10 | 14 | 19 | 28 | |

[1] Sample from pit on Force street just east of the town of Estevan, 115 miles southeast of Regina.

*Table II.—Results of Laboratory Analyses of Textures of Sands.*[1]

| Map No. | Total percentages retained on sieves of | | | | | | Passing |
|---|---|---|---|---|---|---|---|
| | 8 mesh | 14 mesh | 28 mesh | 48 mesh | 100 mesh | 200 mesh | 200 mesh |
| 1 | 38 | 70 | 92 | 98 | 99 | 99 | 0·3 |
| 8 | 18 | 47 | 89 | 97 | 99 | 99 | 0·5 |
| 10 | 29 | 48 | 71 | 89 | 97 | 98 | 2 |
| 17 | 17 | 41 | 73 | 92 | 98 | 99 | 0·5 |
| 20 | 25 | 50 | 77 | 91 | 99 | 100 | 0·3 |
| 23b | 38 | 66 | 89 | 97 | 99 | 99 | 0·4 |
| 44a | 10 | 21 | 46 | 73 | 93 | 98 | 2 |
| 44b | 8 | 24 | 67 | 93 | 99 | 99 | 0·4 |
| 45a | 49 | 61 | 78 | 91 | 95 | 98 | 2 |
| 45c | 1 | 1 | 4 | 17 | 38 | 62 | 28 |
| 45h | 12 | 26 | 59 | 92 | 99 | 99 | 0·3 |
| 47b | 18 | 39 | 67 | 90 | 97 | 99 | 1 |
| 48b | 18 | 39 | 69 | 92 | 99 | 100 | 0·3 |
| 58 | 29 | 61 | 86 | 94 | 98 | 99 | 1 |
| 63 | 24 | 54 | 84 | 95 | 98 | 99 | 1 |
| 67 | 15 | 34 | 56 | 81 | 97 | 99 | 1 |
| 100[2] | 18 | 36 | 72 | 94 | 97 | 98 | 2 |

[1] Duplicate tests were run on each sample and the results are correct to within 5 per cent.
[2] Sample from pit on Force street just east of the town of Estevan, 115 miles southeast of Regina.

*Lithological and Mineral Composition.* The durability of the gravels in road macadam and to some extent the strength of cement mortars made from them are dependent on their pebble composition. Analyses of the percentages of the various rock types composing the gravels are given in Table III. The analyses were made on pebbles over ¼-inch in size and show that the gravels are remarkably uniform in their pebble composition. Certain samples from the Pilot Butte deposit, for instance, resemble gravels from Lumsden or Estevan as closely as they do other samples from the same pit. From 70 to 90 per cent of the gravels are made up of a buff-coloured limestone or dolomite and granitic rocks, i.e. granites, diorites, and their gneisses. There is some trap rock, schist, and shale in practically every sample and quartzite and sandstone are common. A quantitative mineral analysis was also made of two samples of the sand under ¼-inch, one from Findlater and the other from Lumsden, map Nos. 1 and 23. Here again the resemblance in composition is remarkably close. It seems also that the finer portions of the sands are made up of harder materials than the coarser. The sands were separated on the various screens into lots of seven sizes and each lot determined separately. Dolomite or limestone forms 40 per cent of the sand retained on 8 mesh, and there are small percentages of granite diorite, trap, etc., in the coarse sand. but in the sand smaller than 28 mesh, rock fragments are practically absent except for a few grains of trap and dolomite. The sand grains passing the 48 mesh, less than 0·012 inches in diameter, are made up of mineral rather than rock fragments, 60 to 75 per cent of which is quartz, about 3 per cent feldspar, 10 to 20 per cent mica, and 5 to 10 per cent hard, black minerals like magnetite or hornblende. From there down the composition is about the same. Quartz is present in all the sizes and increases from 15 per cent in the 8 mesh material to 66 per cent in grains passing 14 and held in the 28 mesh. Probably more than half of the material passing the 200 mesh, with diameter less than 0·003 inches, is made up of clay and fine particles of the alkalic crust found on the gravel pebbles; the remainder resembles the slightly coarser sand described above. The dolomite and limestone pebbles found in the gravels resemble outcrops of Palæozoic limestones and dolomites lying in a northwest trending belt some 300 miles to the northeast of this district, and are undoubtedly derived from them.

*Table III.—Pebble Composition of the Gravels.*

| Map No. | Trap. | Andesite. | Rhyolite and quartz porphyry | Quartzite | Quartz and flint | Diorite gneiss | Fine-grained granite and granite gneiss | Limestone and dolomite | Coarse granite | Mica gneiss and schist | Sandstone | Feldspar | Shale | Percentage of weathered pebbles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 9 | 2 | | 1 | 1 | | 31 | 40 | 4 | 3 | 4 | | 4 | high |
| 2 | 12 | | | 2 | | | 33 | 47 | | 1 | 3 | 1 | 1 | 21 |
| 4 | 3 | | | 3 | | | 45 | 39 | | 3 | 6 | | | 33 |
| 8 | 3 | 3 | | 3 | | 8 | 26 | 42 | | 5 | 5 | 2 | 3 | 11 |
| 10 | 14 | | 1 | | | 3 | 26 | 42 | 3 | 1 | 6 | | 4 | 25 |
| 17 | 7 | | | 11 | | | 36 | 40 | | 2 | | | 4 | 18 |
| 20 | 5 | 3 | | 2 | | 10 | 20 | 47 | | 10 | | | 3 | 15 |
| 21 | 6 | | | 9 | 3 | | 18 | 44 | 3 | 6 | | | 12 | 5 |
| 22 | 11 | | | | | | 30 | 42 | | 11 | | | 6 | 28 |
| 23 | 12 | | 2 | | | | 28 | 48 | 4 | 6 | | | | 20 |
| 20 and 23 | 12 | 1 | 2 | 2 | 1 | 7 | 21 | 46 | 2 | 4 | | 1 | 1 | 17 |
| 36 | 12 | | | | | 8 | 30 | 30 | | 7 | 5 | | 8 | 17 |
| 37 | 7 | | | 12 | 2 | | 28 | 40 | | | 5 | | 5 | 25 |
| 44 | 9 | 1 | | 4 | | | 35 | 38 | | 1 | 7 | 1 | 4 | 21 |
| 41 | 3 | | | 3 | | | 44 | 47 | 3 | | | | | 19 |
| 45a | 9 | | 2 | 3 | | 1 | 32 | 42 | | 5 | 5 | | 1 | 20 |
| 45g | 7 | | | | | | 34 | 51 | | 3 | 2 | | 3 | 17 |
| 44a | 9 | 3 | | | | | 34 | 47 | | 6 | | | | 25 |
| 47 | 10 | 1 | 1 | 2 | 2 | | 25 | 46 | 2 | 3 | 7 | | 1 | |
| 48 | 9 | 1 | | 6 | 6 | 1 | 26 | 48 | 2 | | | | 1 | 20 |
| 53 | 7 | | | | | | 22 | 63 | | | 4 | | 4 | 19 |
| 58 | 9 | 1 | | 7 | 1 | 3 | 32 | 39 | 2 | | 3 | | 3 | 24 |
| 62 | | | | | | | 34 | 53 | | 2 | 9 | 2 | | 27 |
| 63 | 8 | | 4 | 10 | | | 26 | 40 | | 6 | 4 | | 2 | 20 |
| 65 | 12 | | 4 | 14 | | | 24 | 46 | | | | | | 27 |
| 66 | 2 | 5 | | 2 | | 5 | 15 | 55 | | 5 | 8 | | 2 | 15 |
| 67 | 7 | 3 | | | | | 20 | 60 | | 7 | 3 | | | 20 |
| 68 | 7 | | 2 | 2 | 2 | 4 | 22 | 56 | | | | | 5 | 20 |
| 72 | 3 | | | | | | 37 | 51 | 3 | | 3 | | 3 | 14 |
| 72 | 6 | | | | | 8 | 19 | 47 | 3 | 6 | 5 | | 6 | 8 |
| 73 | 23 | | | 2 | | | 32 | 34 | 2 | | | | 2 | 25 |

*Secondary Alteration.* Nearly all the gravels exhibit the same features in regard to the depth and character of weathering they have undergone and the secondary crusts with which they are coated. At the surface there is a layer of soil with organic matter from 6 inches to a foot thick; below that and passing up into it is a belt of firmly cemented gravel or sand covered with a thick white coating of lime carbonate and probably other alkali salts. The white crust is abundant for a distance of 1 to 2 feet and was observed down to depths of 9 feet from the surface in the coarser gravels. It is thicker on the under side of the pebbles. Crusts of reddish brown iron oxide were seen from the first few feet downwards to the greatest depths at which the gravels were exposed; in rare cases, where there is clay over the gravel, the crust is black. The upper foot or two of the gravel does not exhibit the intense zone of weathering seen in practically all eastern gravel deposits.

### *Commercial Possibilities.*

Gravels and sands may be used in road work as macadam gravel, in concrete road construction, or as parts of the various forms of bituminous surfaces.

*Macadam.* Macadam gravels should be durable and cement rapidly into a hard impervious mass under the action of traffic. Their durability is dependent partly on the kinds of rocks of which they are composed and partly on their texture, that is, the amount of coarse stone present. In Table III on page 9 the kinds of rock of which the gravels are composed are arranged from left to right in the order of their average durability, beginning with the toughest and most resistant. It will be seen that 70 to 90 per cent of the gravel over ¼ inch is composed of stone that is neither very soft nor very tough and hard. Several samples were tested in the abrasion machine,[1] Table IV, and the results, expressed in per cent of wear, indicate that the gravels can be used economically as macadam gravels on roads carrying up to 300 vehicles per day if properly constructed. Because of the uniformity in pebble composition and degree of weathering in the gravels these results can be extended to nearly all of the gravels examined.

This does not mean that the gravels dug from any of the pits will make satisfactory road surfaces, but that if screened through a ¼-inch screen and recombined in the proportions of not less than 60 per cent gravel to 40 per cent of sand, the material may be expected to make a fairly durable road surface. Most of the gravels examined are very sandy, Table VI, and some of the sand should be screened out if they are to be used on main roads. Clay roads subjected to light traffic have, nevertheless, been greatly improved by the use of sandy gravel or even coarse, hard, sand, when no better material was available. From this standpoint every one of the larger deposits mapped in this area can be considered a valuable source of road material.

The cementing values of all the gravels tested are high, indicating that they will bind rapidly into a firm road-bed. The cementing value is doubtlessly affected by pebble composition and the amount of crust present on the pebbles, and since these conditions are nearly the same for all the gravels examined it may be taken for granted that they will all bind readily in a road-bed.

The only roads within this area made of gravel are at Lumsden These roads are made without sprinkling or rolling. The material seems to bind rapidly and wear fairly well under light to medium traffic conditions.

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[1] Engineers generally require that broken stone that is to be used for macadam work should have a percentage of wear of not over 6, and if the traffic is moderately heavy, from 100 to 300 vehicles per day, not over about 3·5. Gravel should show a lower per cent of wear in the abrasion machine than broken stone of the same road-making quality. A cementing value of 50 is considered good, and of 100 or over excellent. For a discussion of laboratory tests upon stone and gravel, the reader is referred to Mem. 85, Geol. Surv., Can., pt. I. More detailed descriptions of the tests and discussions of the results of tests are to be found in Bulls. 347 and 370, U.S. Dept. Agric., Wash., D.C., the latter by Prevost Hubbard and F. H. Jackson, jun., and in an article on "Nonbituminous road materials" by L. Reinecke, published in Economic Geology, vol. XIII, No. 8, Dec. 1918, pp. 557–597.

*Table IV.—Results of Tests Upon Gravels and Sands.*

| Map No. | Average specific gravity | Percentage voids |  | Wear |  |  |  | Cementing value |
|---|---|---|---|---|---|---|---|---|
|  |  | Loose | Compacted | Percentage |  | French coefficient |  |  |
|  |  |  |  | 1 | 2 | 1 | 2 |  |
| 1...... | 2·71 | 34·4 | 27·2 | 2·6[1] | 2·2 | 15·2 | 18·2 | 77 |
| 8........ | 2·69 | 36·32 | 29·6 |  |  |  |  | .... |
| 10....... | 2·69 | 30·4 | 24·0 | 2·3[1] | 1·4 | 17·2 | 28·3 | 117 |
| 17..... | 2·70 | 34·2 | 27·5 |  |  |  |  | .... |
| 20....... | 2·69 | 33·7 | 26·5 | 1·8[2, 3] | 1·04 | 22·2 | 38·4 | 88 |
| 23...... | 2·70 | 32·5 | 24·9 | .... | .... | .... | .... | 93 |
| 44a........ | 2·67 | 35·8 | .... | 4·0[1, 4] | 1·9 | 10·0 | 20·4 | 120 |
| 44b........ | 2·68 | 36·6 | 30·4 | .... | .... | .... | .... | 69 |
| 45a........ | 2·71 | 29·8 | 19·1 | 3·4[2] | 2·1 | 11·8 | 19·0 | 106 |
| 45a...... | .... | .... | .... | 4·2[1] | 2·4 | 9·5 | 16·3 | .... |
| 45b........ | 2·67 | 38·0 | 29·7 | .... | .... | .... | .... | 107 |
| 47....... | 2·70 | 30·8 | 23·7 | 2·5[2] | 1·7 | 15·9 | 22·8 | 97 |
| 48........ | 2·68 | 32·0 | 25·3 | 1·5[1] | 1·3 | 26·5 | 31·7 | 80 |
| 58......... | 2·69 | 32·4 | 24·6 | 4·3[1] | 2·6 | 9·4 | 15·4 | 120 |
| 63......... | 2·68 | 37·7 | 29·7 | .... | .... | .... |  | .... |
| 67......... | 2·67 | 31·4 | 24·5 | .... | .... | .... | .... | .... |
| 100......... | 2·69 | 34·3 | 27·5 | 3·4[2] | 1·9 | 11·6 | 20·6 | 130 |

[1] Abrasion test made on material retained on ½ and passing 2-inch screen, because of lack of sufficient coarse material.

[2] Abrasion test made on material retained on ½ and passing 2-inch screens.

The run on each sample was repeated after washing, drying, and weighing, the results being expressed in columns 1 and 2.

[3] Wear on a sample of 20 and 23 combined.

[4] Wear on a sample of 44a and 44b combined.

*Concrete.* The principal factors that affect the value of sand or gravel used in concrete work are freedom from impurities, texture, and mineral composition, of which the first two are the most important.

Impurities. Organic material such as the loam in the top soil, and clay, especially in cases where it sticks to the pebbles, are considered impurities in gravel aggregates because their presence in appreciable quantities in the aggregates tends to produce a much weaker bond in the concrete mortar than when clean gravels of the same character are used.

Abrams and Harder[1] have devised a quantitative chemical test for measuring the amount of organic impurities present in sands. They express their results as colour values, that is the parts of tannic, or some equivalent organic acid present per million of the sand in weight. They have found that there is an approximate reduction of 10 to 20 per cent between the compressive strength of a 1 to 3 mortar made of clean sand, colour value 0, and of a mortar from the same sand with a colour value of 250. A colour value of 500 is equivalent to a reduction of 15 to 30 per cent and so on. All of the seventeen sands tested in the laboratory were collected from material lying below the thin zone of surface soil, which is, of course, full of organic material. The sand from Estevan had a colour value of 30, the fine silt from Pilot Butte 20, the others ranged from 0 to 10. It is evident that there are no appreciable amounts of organic impurities in the gravels lying below the soil belt. Table II will show that the amount of material passing the 200-mesh screen is low, except in the case

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[1] Abrams, Duff A., and Harder, Oscar E., "Colorimetric test for organic impurities in sands": Circular No. 1, Structural Materials Research Laboratory, Lewis Inst., Chicago, 1917.

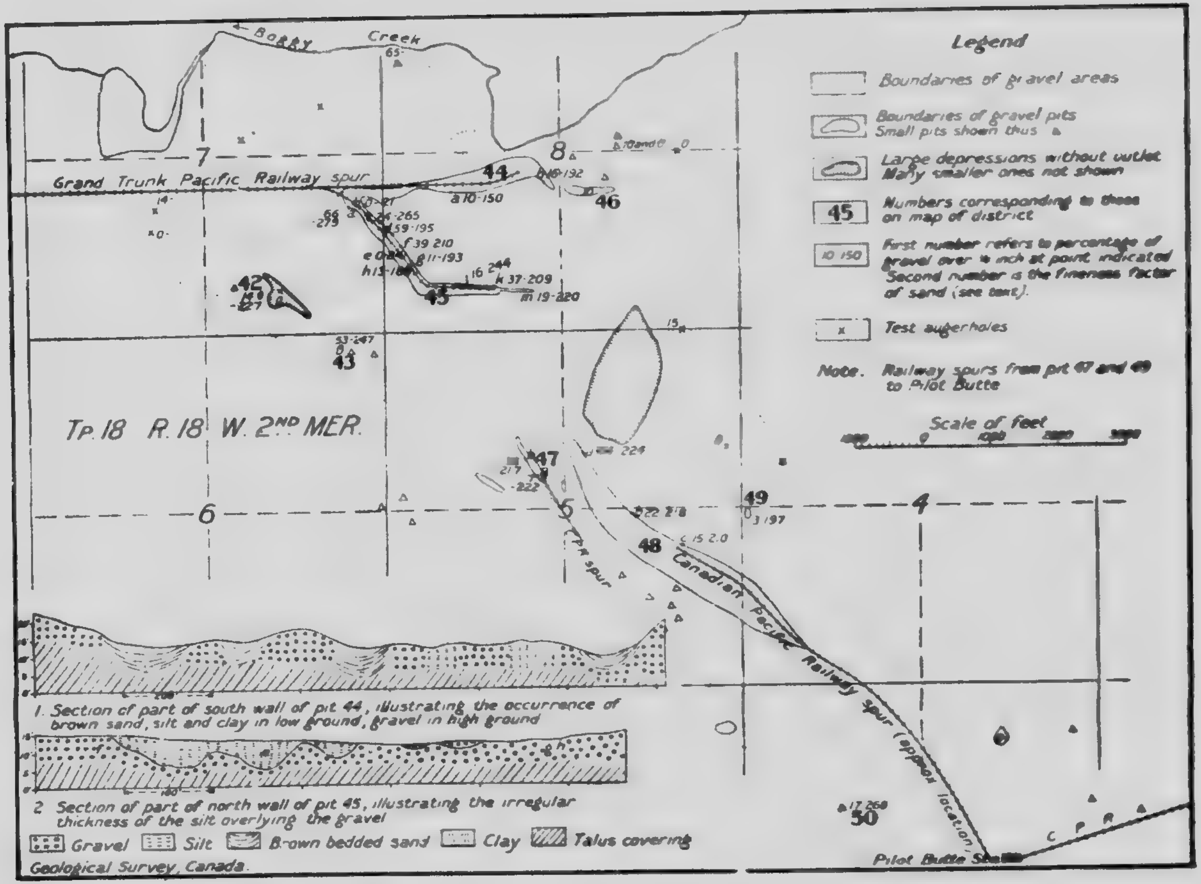
Bobby Creek
Grand Trunk Pacific Railway spur
Tp. 18 R. 18 W. 2ND MER.
Canadian Pacific Railway spur (approx location)
C.P.R. spur
C.P.R.
Pilot Butte Sta.
42
43
44
45
46
47
48
49
50
Legend
Boundaries of gravel areas
Boundaries of gravel pits
Small pits shown thus
Large depressions without outlet
Many smaller ones not shown
Numbers corresponding to those on map of district
First number refers to percentage of gravel over ¼ inch at point indicated
Second number is the fineness factor of sand (see text).
Test augerholes
Note. Railway spurs from pit 47 and 49 to Pilot Butte
Scale of feet
1. Section of part of south wall of pit 44, illustrating the occurrence of brown sand, silt and clay in low ground, gravel in high ground
2 Section of part of north wall of pit 45, illustrating the irregular thickness of the silt overlying the gravel
Gravel
Silt
Brown bedded sand
Clay
Talus covering
Geological Survey, Canada.

Figure 2. Gravel deposits northwest of Pilot Butte.

of the silts, and as only a portion of that is clay the amount of clay present in the coarser sands and gravels is too small to seriously affect the strength of the concrete. The white carbonate and alkali crust found on gravel lying near the surface is a source of weakness in concrete, because it prevents the cement from setting on the solid portion of the pebble; it would probably, therefore, be advisable to omit the upper foot or two of the deposits where this crust is thick, when concrete of high strength is required.

Texture. Modern practice[1] requires that concrete aggregates be separated into coarse and fine aggregates. Most commonly the separation is affected on the ¼-inch screen. In this report the material retained on and passing a ¼-inch screen is referred to as "gravel" and "sand" respectively. For road pavement construction the gravel and sand are recombined in proportions which vary from 1 of sand to 2 of gravel, to 2 of sand to 3 of gravel. Concrete roads have, however, been built with 3 parts of sand to 4 of gravel. The results of analyses shown by numbers on the map of the deposit at Pilot Butte (Figure 2) and given in Table VI for the whole area, indicate that less than 30 per cent of the larger deposits are over ¼ inch in size. This means that the exploitation of the deposits for concrete road work will involve the production of an excess of sand.

The textures of the sands under ¼ inch, however, lie in nearly all cases between limits that are considered favourable for the production of strong mortars. The committee on concrete, of the American Society for Testing Materials,[2] recommends that not over 30 per cent of the fine aggregate shall pass a sieve having 50 meshes (practically equivalent to 48 mesh in our analyses) and not more than 5 per cent pass a sieve having 100 meshes to the linear inch. Tables II and VI show that all of the sands conform to these specifications. The silt, No. 45c (See plan and profile of Figure 2) can be easily distinguished from the sands and gravels and is not referred to as "sand" in this discussion. Jackson[3] has made a series of experiments in which a sand composed nearly wholly of quartz grains was artificially graded into the portions passing one sieve and retained on the next smaller of the following series of sieves: ¼ inch, 10 mesh, 20 mesh, 30 mesh, 40 mesh, 50 mesh, and the portion passing 50 mesh. These were recombined in sixty different combinations and the compressive and tensile strengths of 1 to 2½ cement mortars made with them were tested at the end of seven days. The writer has plotted a part of the results of Jackson's work on Figure 1. The curves, Nos. 1 and 4, on the extreme left and right of Figure 1 enclose a zone within which lie the curves for all the combinations used by Jackson. The sands whose curves of texture lie in the zone enclosed between curves Nos. 1 and 3 form mortars whose compressive strengths lay with 60 per cent of the maximum strength obtained from the series. Those lying to the right of this zone or only partly within it gave lower compressive strength results.

If the sixteen sands from the Regina district whose textures were analysed in the laboratory be plotted in this diagram it will be found that the greater number of them fall within this zone. Those not wholly within the zone lie less than 5 per cent outside it, except sample 45a, which includes more coarse sand than the combinations tested by Jackson. The curves of the sands tested from Regina would show to even better advantage in zones drawn in the same way for tensile strength.

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[1] "Concrete road specifications, adopted by the Concrete Road Institute, 1914". Assoc. of Portland Cement Manufacturers, Phil., Pa.

[2] "Final report of the joint committee on concrete and reinforced concrete": Proc. Am. Soc. Test. Mater., vol. XVII, 1917, pt. I, p. 216.

[3] Jackson, F. H., jun., "Influence of grading on the value of fine aggregate used in Portland cement concrete construction": Jour. of Agric. Research, vol X, No. 5, July 30, 1917, pp. 264–274.

Mortar Tests. In Table V the results are given of tests upon mortars made with the various sands and Portland cement. The mortars were mixed in the proportion of 3 of sand to 1 of cement with distilled water; they were moulded into cylinders and briquettes in the standard way and broken in standard compressive and tensile strength machines at the end of seven and twenty-eight day periods. Mortars made of standard Ottawa sand and cement in the same proportions were moulded with each batch and broken at the same time. The results are expressed in percentages of the strengths of the sands tested, to that of the corresponding standard sand. The strength of the standard sand varied, the average being: compressive strength 1,118 pounds per square inch at 7 days, 1,602 at 28 days; tensile strength 260 pounds per square inch at 7 days, 321 at 28 days.

The sixteen sands tested meet the requirements that they shall have compressive and tensile strengths at the end of seven days at least equal to the compressive and tensile strengths of 1 to 3 mortars of the same consistency made of the same cement and standard Ottawa sand[1]. All of the sands showed greater strengths at twenty-eight days than at seven, although the percentages of their strengths relative to the standard sand were in some cases less. The silt No. 45e does not meet these requirements. The results shown in Table V vary greatly, however. These variations are due in part to variations in the strength of the standard sand from day to day and are not believed to be a fair measure of the relative values of the sands in practical concrete work. There can be no question, however, that the silts, with fineness factors of from 20 to 50, will not make satisfactory cement mortars and sands with a fineness factor of less than 100 or more than 300 should be tested before being used in important work.

*Table V.—Results of Tests on Sand Mortars.*

| Map No. | Per cent of strength relative to that of standard Ottawa sand | | | | Fineness factor |
|---|---|---|---|---|---|
| | Compressive strength | | Tensile strength | | |
| | 7 days | 28 days | 7 days | 28 days | |
| 1 | 101 | 65 | 153 | 131 | 298 |
| 8 | 176 | 138 | 142 | 134 | 251 |
| 10 | 136 | 98 | 156 | 118 | 237 |
| 17b | 145 | 180 | 114 | 107 | 223 |
| 20 | 119 | 129 | 124 | 111 | 243 |
| 23 | 147 | 162 | 181 | 186 | 290 |
| 44a | 164 | 217 | 127 | 122 | 150 |
| 44b | 130 | 169 | 105 | 92 | 192 |
| 45a | 101 | 100 | 108 | 86 | 279 |
| 45e | 49 | 75 | 48 | 53 | 24 |
| 45h | 153 | 165 | 114 | 111 | 189 |
| 47b | 143 | 211 | 118 | 120 | 217 |
| 48b | 154 | 159 | 166 | 157 | 218 |
| 58 | 165 | 134 | 145 | 115 | 270 |
| 63 | 139 | 154 | 115 | 130 | 257 |
| 67 | 145 | 161 | 104 | 100 | 186 |
| 100[1] | 101 | 103 | 122 | 122 | 220 |

[1] Sample from Force street, east of Estevan, 115 miles southeast of Regina.

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[1] Proc. Am. Soc. Test. Mater., vol. XVII, pt. I, p. 216.

*Bituminous Roads.* Sands and gravels are used as part of the aggregate in certain kinds of bituminous road surfaces. The remarks applied to the value of these gravels when used in waterbound macadam would hold also for a gravel road bound with bitumen, but in the latter instance it would be much more important, because of the increased cost of the road, to screen out the excess of sand and use a properly sized aggregate, and the alkali crust would be a detriment to the solid binding of the road rather than an advantage, as in waterbound macadam.

Sand is used in the wearing course of sheet asphalt surfaces and the latest recommendations[1] require that 12 to 45 per cent of the sand pass the 10 and be retained on the 40 mesh and 20 to 40 pass the 80 and be retained on the 200 mesh. Thus only the finer sands or the finer portions of the deposits would be suitable for use in sheet asphalt work. The finer parts of the deposits since they contain 60 to 70 per cent of quartz (page 8) would, however, be much more durable than the gravel portions tested in Table IV.

### *Development and Utilization.*

Large sheets of gravel and sand have been worked near Renvyle station on the Canadian National railways, and at Pilot Butte, Lumsden, Disley, and Findlater. A large part of this was sold in Regina and used in the construction of concrete street foundations, sidewalks, and buildings. A large amount was also developed and used for railway ballast. Gravel sold at about $2.25 per yard, furnished at the work, in Regina, in 1913 and 1914. Large deposits, practically undeveloped, are found at the Ruthenian settlement of Rastadt north of Lajord, in an old valley course west of Buffalo Pound lake just north of Rocky lake, and another 3 or 4 miles to the northeast of the last, west of High Hill creek, and just across the Qu'Appelle valley from Disley. The amounts avaliable from the larger deposits, except that at Renvyle, are of the order of 1,000,000 cubic yards. Besides the large deposits there are numerous small pockets of gravel and sand in the hilly belt northeast of Regina, along some of the larger creek valleys, and in the isolated hills southwest of Condie. These have been developed in a small way and used locally on the farms for concrete work in barn and house foundations and floors, and the fine sand for making lime mortar.

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[1] "Progress report of the special committee on materials for road construction and on standards for their test and use"; Am. Soc. Civ. Eng., New York, Jan. 1917, p 1629.

# CHAPTER II.

## *Table VI.—Texture of the Gravels.*

| [1]Map No. | Sample from surface in feet | Per cent gravel over ¼ inch | Per cent sand | Cumulative percentages of sand retained on |  |  |  |  | Fineness factor | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | 8 mesh | 14 mesh | 28 mesh | 48 mesh | Passing 48 mesh |  |  |
| 1 | 2 to 8½ | 31 | 69 | 38 | 70 | 92 | 98 | 2 | 298 | 1. Tested. 1 and 2 probably fair average of gravel in two pits. The upper foot, not analysed, is coarser over a large part of area, especially in pit 3 and west of pit 1. |
| 2 | 2 to 9 | 43 | 57 | 63 | 75 | 85 | 93 | 7 | 316 |  |
| 3 | 1 to 6 | 31 | 69 | 32 | 56 | 77 | 94 | 6 | 259 |  |
| 4 | 1½ to 7½ | 16 | 84 | 24 | 53 | 76 | 93 | 7 | 246 | Texture appears uniform in this pit. |
| 5 |  |  |  |  |  |  |  |  |  | Four small pits west of Rocky lake. Fairly coarse gravel in western and southern pits, sand in northern, fine gravel in eastern |
| 6 |  |  |  |  |  |  |  |  |  | Fine gravel in pits on road. For one-half mile west coarse gravel shows in gopher holes. This is a promising deposit. |
| 7 |  | 5 | 95 |  |  |  |  |  |  | Very sandy at east end of area, more gravelly on south edge |
| 8 |  | 19 | 81 | 18 | 47 | 89 | 97 | 3 | 251 | Tested. Rather sandy gravel on surface of top of ridge. Some coarse gravel in places along southeast edge |
| 9 |  |  |  |  |  |  |  |  |  | Coarse gravel in pit west of road, silt and gravel east of road |
| 10 | 2 to 8 | 41 | 59 | 29 | 48 | 71 | 89 | 11 | 237 | Tested. Analysis in main pit. Upper 2 feet clay silt |
| 11 |  |  |  |  |  |  |  |  |  | Sand pit at west end, coarse gravel at east end. Not promising |
| 12 |  | 20 | 80 |  |  |  |  |  |  | This end of deposit appears finer than at pits 13 and 14 |
| 14 |  | 30 | 70 |  |  |  |  |  |  | Upper foot in 14 coarser than estimate |
| 15 |  | 15 | 85 |  |  |  |  |  |  | Area to west sandy on surface along north and coarser along south boundary |
| 16 |  | 25 | 75 |  |  |  |  |  |  | Coarse sand in test hole 11 feet deep 150 yards to northwest |
| 17a |  | 39 | 61 | 46 | 70 | 85 | 94 | 6 | 295 | North wall, west end of pit |
| 17b | 2 to 6 | 20 | 80 | 17 | 41 | 73 | 92 | 8 | 223 | Tested north wall, middle of pit. Irregular floor of boulder clay |
| 18 |  |  |  |  |  |  |  |  |  | Irregular floor boulder clay, gravel fine, coarser south of railway |
| 19 |  |  |  |  |  |  |  |  |  | Three small pits along face ridge varying in texture |
| 20 |  | 20 | 80 | 25 | 50 | 77 | 91 | 9 | 243 | Tested. Group of pits here fairly uniform in texture, also the one at west end of area |
| 21 |  | 23 | 77 | 23 | 48 | 71 | 91 | 8 | 233 |  |
| 22 |  | 12 | 88 | 20 | 44 | 69 | 94 | 6 | 227 | Surface sandy to north. |
| 23a | 1½ to 5½ | 13 | 87 | 32 | 61 | 82 | 95 | 5 | 270 | a. From small pit just south of road crossing. b. On southeast wall main pit. Tested. |
| 23b | 1½ to 5 | 34 | 66 | 38 | 66 | 89 | 97 | 3 | 290 | c. Near west end of main pit. The east end has an irregular floor of boulder clay. Gravel finer at west end |
| 23c | 1 to 6 | 7 | 93 | 15 | 54 | 80 | 95 | 5 | 244 |  |
| 24 |  |  |  |  |  |  |  |  |  | Three pits lying on hill slope below pit 23, the two lower ones are in irregular masses of gravel lying in boulder clay |
| 25 |  |  |  |  |  |  |  |  |  | Three small pits. 20 per cent of gravel in pit in sec. 14, about the same per cent of gravel in sec. 11. Coarse gravel in sec. 1. |
| 26 |  |  |  |  |  |  |  |  |  | Four small gravel pockets in boulder clay. The northern pit is sandy, the western covered with 4 feet of clay. The southern pit is very small, all are unimportant. |
| 27 |  | 25 | 75 |  |  |  |  |  |  | Thin sheet of fairly coarse gravel in sec. 14. Very small pockets in sec. 36. |
| 28 |  | 0 | 100 |  |  |  |  |  |  | Very fine sand in sec. 26. Small gravel pocket in clay in sec. 24. |
| 29 |  | 15 | 85 |  |  |  |  |  |  | Well stratified, clean silts and gravels along road. A promising small deposit above clay bluff on creek slope to north, is rather inaccessible. |
| 30 |  |  |  |  |  |  |  |  |  | East pit bouldery, west pit interstratified sand, gravel, and boulder clay, with boulder clay overburden. |

[1]For location see map in pocket.

## Table VI.—Texture of the Gravels—Continued.

| [1]Map No. | Sample from surface in feet | Per cent gravel over ¼ inch | Per cent sand | Cumulative percentages of sand retained on | | | | | Fineness factor | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 8 mesh | 14 mesh | 28 mesh | 48 mesh | Passing 48 mesh | | |
| 31 | | | | | | | | | | Alternate beds and lenses of boulders, gravel, and grey silt 3 to 5 feet long, with clay lenses. |
| 32 | | 50 | 50 | | | | | | | 1 to 3 feet of boulder clay over gravel. |
| 33 | 1 to 2 | 50 | 50 | | | | | | | Pit east of road covered by boulder clay, west of road there is sandy gravel. |
| 34 | | 60 | 40 | | | | | | | The two analyses represent variations in large pit in sec. 26: they are 15 feet apart. Sandy gravel in sec. 23 |
| | | 15 | 85 | | | | | | | |
| 35 | | 0 | 100 | | | | | | | Main pit in sec. 19 contains silt probably with 50 per cent passing 48 mesh. Just to north is a small deposit 50 per cent gravel. The pit in sec. 20 is in sand |
| 36 | 3 to 6 | 39 | 61 | 25 | 48 | 71 | 95 | 5 | 239 | Alternate lenses of coarse gravel and sand under boulder clay. |
| 37 | 2 to 10 | 16 | 84 | 19 | 32 | 54 | 83 | 7 | 188 | Well sorted sands and gravels overlain by up to 3 feet of boulder clay. Estimate at west end. |
| 38 | 3 to 7 | 30 | 70 | | | | | | | In east pit 3 to 4 feet of boulder clay over 4 feet or so of unsorted gravel. West pit unimportant |
| 39 | | | | | | | | | | In sec. 1, tp. 19, range 19, there is a sand pit, in section 14 to the north and secs 24 and 35, tp 18, range 19, there are surface indications of gravel |
| 40 | | | | | | | | | | Sand in pits and on surface in these areas |
| 41 | 2 to 7 | 24 | 76 | 47 | 63 | 79 | 92 | 8 | 281 | Pit at house, pockets of gravel in clay at east end, coarse gravel in middle and sandier gravel at west end. Sample probably an average. Similar gravel northeast of house and farther north near creek. Bouldery sand and sand in two pits to south. |
| 42 | 1 to 6 | 14 | 86 | 22 | 42 | 70 | 93 | 7 | 227 | The texture of the large deposit, about 860 acres including numbers 42 to 50, is shown by numbers on the map in Figure 2. Numbers 44a, b, 45a, e, h, 47b, and 48b have been tested in the laboratory. The main aggregate of this large deposit consists of coarse sand carrying a small proportion of gravel, from 10 to 40 per cent. In this are small pockets of coarser gravel represented by analyses 43, 45a, and 45d and over it in places are deposits of silt, analyses 45b and e, and also bedded brown sand, till, and sandy clay (Plate II). The silt, brown clay, etc., is confined almost exclusively to the top layers underlying the numerous small "sags," depressions without outlet, which are found throughout the deposit (Plate I and profile Figure 2). In places, also, such as west half of the north, and east half of the south walls of pit 48 there are heavy deposits of silt underlying higher ground. To the southeast of the area as sketched, there is a large sand deposit, which is an extension of the main one but carries little or no gravel. The proportion of gravel, material over ¼ inch, is low for concrete if the recommended proportions of approximately 2 of gravel to 1 of sand are used. The "sand" portion of the aggregate is uniformly of good mortar-making qualities |
| 43 | 1 to 6½ | 53 | 47 | 37 | 53 | 69 | 88 | 12 | 247 | |
| 44a | | 10 | 90 | 10 | 21 | 46 | 73 | 17 | 150 | |
| 44b | | 16 | 84 | 8 | 24 | 67 | 93 | 6 | 192 | |
| 45a | 1 to 7 | 66 | 34 | 49 | 61 | 78 | 91 | 10 | 279 | |
| 45b | 2 to 8 | 0 | 100 | 1 | 1 | 4 | 15 | 85 | 21 | |
| 45c | 1 to 5 | 24 | 76 | 41 | 51 | 81 | 92 | 8 | 265 | |
| 45d | 1 to 6 | 59 | 41 | 34 | 34 | 49 | 78 | 22 | 195 | |
| 45e | 1½ to 8 | 0 | 100 | 1 | 1 | 4 | 18 | 82 | 24 | |
| 45f | | 39 | 61 | 31 | 41 | 59 | 85 | 15 | 216 | |
| 45g | ½ to 5½ | 11 | 89 | 13 | 29 | 57 | 94 | 6 | 193 | |
| 45h | ½ to 5½ | 13 | 87 | 12 | 26 | 59 | 92 | 8 | 189 | |
| 45j | 1½ to 5½ | 16 | 84 | 25 | 52 | 75 | 92 | 8 | 244 | |
| 45k | 1½ to 3½ | 37 | 63 | 22 | 38 | 61 | 88 | 11 | 209 | |
| 45m | 1½ to 5½ | 19 | 81 | 19 | 41 | 66 | 94 | 6 | 220 | |
| 46 | | 10 | 80 | | | | | | | |
| 47a | | 7 | 93 | 19 | 44 | 68 | 91 | 9 | 222 | |
| 47b | | 38 | 62 | 18 | 40 | 68 | 91 | 9 | 217 | |
| 48a | | 44 | 56 | 20 | 45 | 69 | 90 | 10 | 224 | |
| 48b | | 22 | 78 | 18 | 39 | 69 | 92 | 8 | 218 | |
| 48c | | 15 | 85 | 18 | 37 | 62 | 93 | 7 | 210 | |
| 49 | | 3 | 97 | 10 | 34 | 61 | 92 | 7 | 197 | |

[1] For location see map in pocket

## *Table VI.—Texture of the Gravels—Concluded.*

| [1]Map No. | Sample from surface in feet | Per cent gravel over ¼ inch | Per cent sand | Cumulative percentages of sand retained on | | | | | Fineness factor | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 8 mesh | 14 mesh | 28 mesh | 48 mesh | Passing 48 mesh | | |
| 50 | | 17 | 83 | 37 | 60 | 79 | 92 | 8 | 268 | |
| 51 | | 0 | 100 | | | | | | | The pits in NE. ¼ sec. 33 are in sand except the small gravel holes on the butte. |
| 52 | | | | | | | | | | Small pockets of sand and gravel in boulder clay. |
| 53 | 2 to 6 | 26 | 74 | 26 | 44 | 66 | 93 | 7 | 229 | In pit gravel, 1 to 4 feet from surface and coarse sand in one place from 4 feet down to ground-water-level at [illegible] feet. Fairly coarse gravel in places south of pit. |
| 54 | | | | | | | | | | Five very small areas. Coarse gravel in the one farthest west, one farthest east is sandy. |
| 55 | | 85 | 15 | | | | | | | Boulder clay on east flank of gravel. |
| 56 | | | | | | | | | | Coarse sand pea size under 2 feet of boulder clay in pit west sec. 15. Other areas mostly undeveloped. |
| 57 | | | | | | | | | | Coarse gravel exposed at northwest end, silt and coarse sand in 5-foot auger hole at south-east end. |
| 58 | | 31 | 69 | 29 | 61 | 86 | 94 | 6 | 270 | West wall 100 yards from north end. Tested. |
| | 2½ to 5¾ | 26 | 74 | 24 | 47 | 69 | 92 | 8 | 232 | East wall 400 yards from north end. |
| | 1½ to 5½ | 5 | 95 | 15 | 28 | 55 | 94 | 6 | 192 | East wall 740 yards from north end, finer sand down to 9 feet. Interbedded sands, marl, and plastic clay in 11-foot test hole between pit and railway. |
| 59 | | | | | | | | | | Sand content high in three pits. |
| 60 | ½ to 5 | 19 | 81 | 21 | 41 | 65 | 93 | 7 | 220 | Test hole on small hill southeast of pit. Sand, silt, and fine gravel exposed in pit. |
| 61a | 2 to 6½ | 6 | 94 | 20 | 50 | 74 | 93 | 7 | 237 | Analysis fair average for pit west of road, pit in road a pocket in boulder clay. |
| 61b | | 0 | 100 | 2 | 12 | 40 | 91 | 9 | 145 | Analyses from pit east of road. |
| 62 | ¼ to 4 | 23 | 77 | 32 | 33 | 47 | 75 | 25 | 187 | Northern pit. |
| | ½ to 4 | 43 | 57 | 39 | 53 | 72 | 93 | 7 | 257 | Analysis of the coarser gravel in southern pit, material varies to clay and silt within 10 feet horizontally. |
| 63 | | 19 | 81 | 24 | 54 | 84 | 95 | 5 | 257 | Analysis in north end of area. Sandier in southern pits. |
| 64 | | 0 | 100 | 22 | 45 | 69 | 93 | 7 | 229 | 2 to 3 feet of silt overlying the sand analysed. |
| 65 | | | | | | | | | | Interbedded sand and gravel. |
| 66 | 1-5 | 19 | 81 | 33 | 60 | 81 | 94 | 6 | 269 | Pit east of school, fairly coarse gravel in hill to north |
| 67 | 1-4 | 19 | 81 | 15 | 34 | 56 | 81 | 19 | 186 | The gravel in this hill varies sharply in texture in places within 15 feet, in others within 50 feet. |
| 69 | 2 to 10 | 29 | 71 | 42 | 58 | 75 | 94 | 6 | 269 | Analyses of pit west of road, sand pit in road. |
| 70 | | | | | | | | | | Both pits very sandy with beds of fine silt. |
| 71 | | | | | | | | | | Pit south of creek is 100 per cent sand, west of creek three pits reveal fine gravel and sand. There is marl in the crossroad to the north. |
| 72 | 2 to 4½ | 21 | 79 | 24 | 43 | 67 | 95 | 5 | 229 | The gravel in this area is rather fine, but coarser than at 71. |
| 73 | | 15 | 85 | | | | | | | Analysis of gravel from 5-foot auger hole at road. |
| 74 | | 5 | 95 | 9 | 22 | 49 | 90 | 10 | 170 | Pit at road just south of creek analysed, other pits with similar gravel on road to south. In road cuts south and west of sec. 14, coarse gravel is exposed, no other excavations within one mile of creek. |
| 75 | | | | | | | | | | Interbedded silt and sand in pit, coarse gravel in road cuts to north. |
| 76 | | | | | | | | | | Sand pit on west edge sec. 12. |
| 77 | | | | | | | | | | 2 fe [illegible] ne gravel over 4 feet of sand. Other areas to northwest not developed. |

[1]For location see map in pocket.

## *Details of Development of the Sands and Gravels.*

*Explanation.* The number at the beginning of each paragraph is the map number. Location is given by township, range, and section, west of 2nd meridian. Amounts excavated and available are obtained as follows: horizontal dimensions by compass and pace traverses, vertical depths by measurement. Where the uses to which the gravel and sand are put have not been mentioned these materials have in nine cases out of ten been used for concrete and plaster work in houses and barns. Abbreviations: tp.—township; sec.—section; C.N.R.—Canadian National railways; C.P.R.—Canadian Pacific railway; G.T.P.—Grand Trunk Pacific railway.

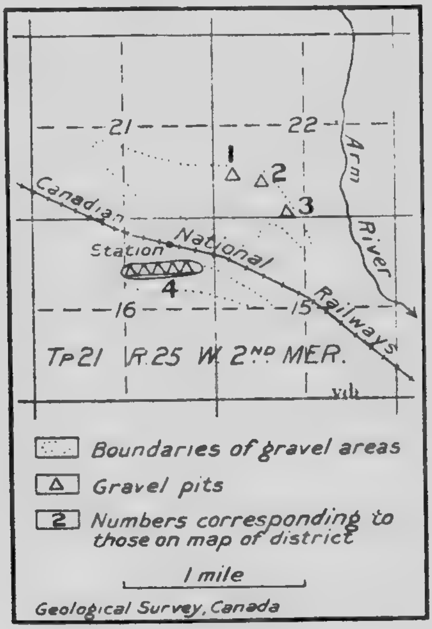

21
22
16
15
1
2
3
4
Arm River
Canadian National Railways
Station
Tp 21 R.25 W. 2ND MER.
vih
Boundaries of gravel areas
Gravel pits
Numbers corresponding to those on map of district
1 mile
Geological Survey, Canada

Figure 3. Gravel deposits at Findlater.

Nos. 1, 2, 3. Tp. 21, range 25, secs. 21, 22, 15. Owners: Margaret Mac han, Findlater; Regina Gravel Supply Co.; Mrs. Fetterley, Spring Hill, Man. About 12,000 cu. yds. excavated, 1,000,000 to 2,000,000 cu. yds. available. Covers about 160 acres, 7 to 12 feet deep in pits. Sold in Regina at $2.15 per cu. yd. unscreened and $3 screened. Used for concrete street foundations and in buildings.

No. 4. Tp. 21, range 25, secs. 15, 16. Owners: C.N.R. and Mrs. Fetterley, Spring Hill, Man. About 330,000 cu. yds. excavated, perhaps 300,000 cu. yds. available. Used for railway ballast.

No. 5. Tp. 18, range 24, secs. 6, 7, 8, 9, 32, 33. The main deposit to east appears to end near No. 5, to west the deposits are small.

No. 6. Tp. 18, range 24, secs. 24, 35, 36. Owners: G. M. Reid; Lowry and Bentley; I. W. Bock. Pit small. In east half of sec. 35 there may be 500,000 to 1,000,000 cu. yds. The gravel at this place looks promising, should be prospected.

No. 7. Tp. 18, range 23, sec. 31; tp. 18, range 24, sec. 36. Owner: Mrs. Thompson, R.R.I., Keystone. Covers 160 acres; 250 cu. yds. excavated, large amount available. Material appears very sandy.

No. 8. Tp. 19, range 23, sec. 4; tp. 18, range 23, secs. 31, 32. Part owners: J. Irving, J. S. and G. M. Reid, R.R.I., Keystone. About 1,000 cu. yds. excavated, may be 500,000 cu. yds. available.

No. 9. Tp. 18, range 23, secs. 21, 22, 28. Amount excavated, 250 cu. yds. Gravel 4 feet deep at pit.

No. 10. Tp. 18, range 23, secs. 10, 15. About 3,500 cu. yds. excavated. Depth at pit, 3 to 9 feet. Covers 70 acres.

No. 11. Tp. 19, range 23, secs. 15, 16. Owner: Mark Turnbull, Disley. Amount excavated, 50 cu. yds., amount available, small. Sandy.

No. 12. Tp. 19, range 23, sec. 13. Amount excavated, 900 cu. yds. (See No. 14.)

No. 13. Tp. 19, range 23, sec. 12. Owner: John Cairnes, R.R.I., Keystone. Amount excavated, 200 cu. yds. (See No. 14.)

No. 14. Tp. 19, range 23, sec. 12. Owner: Harry Creasy, Disley. Amount excavated, 375 cu. yds. Area includes 12, 13, 14, with gravel over 6 feet deep in pits, gravel shows on surface in higher points. Large amount available.

Nos. 15, 16. Tp. 19, range 22, sec. 19. Owner: Wm. T. Ashe, Disley. Amount excavated, 2,750 cu. yds. (See No. 17.)

No. 17. Tp. 19, range 22, sec. 30. Owner: R. T. Leckie, 305 Northern Bank building, Regina. About 45,000 cu. yds. excavated. Deposit, including 15, 16, 17, 18, is 6 to 9 feet deep along edges, 12 to 18 feet for long distances near middle. It covers over 200 acres and contains several million cubic yards. No. 17 is connected by a spur to the C.N.R. It lies on crest of Qu'Appelle valley. Used for concrete work in Regina and elsewhere.

No. 18. Tp. 19, range 22, sec. 29. Owners: B. and T. Campbell, Disley, and R. J. Leckie, Regina. About 100,000 cu. yds. excavated. Part of the deposit which includes pit 17. In sec. 29 the deposit is nearly exhausted.

No. 19. Tp. 19, range 22, sec. 29. School property. Five pits, total yardage excavated, 6,500. Covers about 15 acres 6 to 9 feet deep, in places irregular at east end, 150,000 to 200,000 cu. yds. available. Few cubic yards in deposit in sec. 36 to east.

Nos. 20, 21. Tp. 19, range 21, secs. 32, 31. About 14,000 cu. yds. excavated from pit in sec. 31. Owner: Chas. Mann, Lumsden. Deposit 3 to 15 feet deep, and variable. About 20,000 cu. yds. excavated from pits in sec. 32. Owner: W. McCalmon, Lumsden. Deposit 9 to 15 feet deep. (See No. 23.)

No. 22. Tp. 19, range 21, sec. 32. Owner: John Metcalf, Lumsden. Two pits, 14,000 cu. yds. excavated, deposit 15 feet deep here. (See No. 23.)

No. 23. Tp. 19, range 21, sec. 32. Owner: W. B. Watkins, Lumsden. Amount excavated, 93,000 cu. yds. The deposit, including Nos. 20, 21, 22, 23, is from 2 to 6 yards deep in secs. 32, 31. At the ends and edges the floor is hummocky. If the average depth is considered to be 3 yards there is about 1,500,000 cu. yds. available west of sec. 33. This deposit lies on the crest of the north wall of the Qu'Appelle valley, 200 feet above the C.N.R. track at Lumsden and 1 mile from it. Used in Regina for concrete street foundations, sidewalks, buildings, etc., and in Lumsden for gravel macadam. In Lumsden, the gravel is spread on streets but not rolled, patching is done every year. It appears to bind readily and wear fairly well.

No. 24. Tp. 19, range 21, sec. 33. Four pits lie on hill slope below No. 23. The gravel is pockety and exhausted in most places.

No. 25. Tp. 20, range 21, sec. 14. Small pit, gravel used in Craven for concrete. This is a small pocket in boulder clay, high on slope of valley. Tp. 20, range 21, sec. 11. Three pits, 8,500 cu. yds. excavated, gravel in three knolls near farmhouse and valley bottom. Tp. 20, range 21, sec. 1. Small pit and very small deposit in boulder clay, difficult of access.

No. 26. Tp. 19, range 21, sec. 7, on east slope of Waskana creek. Two small pits, about 500 cu. yds. excavated. Overburden of 3 to 5 feet of silt in larger pit on west side, deposit small. Sec. 7 on west crest Waskana creek. Owner: Alex. McEwen, Lumsden. Two small pits, may be 2,000 cu. yds. available. Used in building concrete foundations. In SE. ¼ sec. 7 there is a gravelly knoll with a test pit. In sec. 7, tp. 19, range 22, there is a small excavation on west slope of creek in shallow deposit of no importance.

No. 27. Tp. 18, range 22, sec. 14. Owner: W. T. Gibbs, Lumsden. About 300 cu. yds. excavated and 3,000 available. Used in concrete foundations and floors. Small pits in secs. 36 and 25 in two small deposits

No. 28. Tp. 17, range 22, sec. 26. Large deposit of fine sand south of track, said to be gravel north of railway. In sec. 24 two old pits on banks of creek, practically exhausted.

No. 29. Tp. 19, range 21, sec. 23. Two pits north of road east slope of Boggy creek. Amount excavated, 350 cu. yds.; amount available, 5,000 to 10,000 cu. yds. Across gully to south is another deposit of about 4,000 cu. yds. and a small one to the east. In sec. 14 about 4,000 cu. yds. lies on slope about 100 feet above and east of Boggy creek; hauling would be difficult.

No. 30. Tp. 19, range 21, sec. 14. Small excavation east of creek, gravel exhausted. West of creek next to railway, pit of about 23,000 cu. yds. Gravel 30 to 45 feet deep under 0 to 15 feet of boulder clay. Difficult to reach by wagon.

No. 31. Tp. 19, range 21, sec. 11. Small pocket on west bank of creek, practically exhausted.

No. 32. Tp. 19, range 20, sec. 6. Owner: Robert Taber, Condie. Amount excavated, 1,350 cu. yds. Covered by 1 to 3 feet of boulder clay. Used in concrete work locally.

No. 33. Tp. 18, range 20, secs. 31, 32, on south wall creek valley. Owners: Chas and E. Cullum, Condie. About 200 cu. yds. excavated, 2 to 4 feet of boulder clay over eastern deposit. Amount available small

No. 34. Tp. 18, range 21, sec. 26. Lies in rounded hill. Two pits; 2,500 cu. yds. excavated, about 500,000 cu. yds. available, estimated from surface indications. Deposit in sec. 23 about 4,000 cu. yds. In sec. 22 is small pit and if gravel considered 5 yds. deep, there is about 40,000 cu. yds. available.

No. 35. Tp. 18, range 20, sec. 19. Owner: Robert Condie, Condie. Three pits; total amount excavated about 11,000 cu. yds., very little material of gravel size, over ¼ inch, available. In sec. 20 there is a small sand deposit.

Nos. 36, 37. Tp. 18, range 21, sec. 12. Owner: George Reilly, Regina. Two pits on north bank creek; amount excavated, 200 cu. yds., amount available, small. Boulder clay overburden, 0 to 4 feet. On north bank larger pits with heavy overburden to south and west. Used locally for concrete work.

No. 38. Tp. 17, range 20, sec. 31, south bank of creek. Amount excavated, 1,700 cu. yds., at east pit; remainder largely covered by clay overburden. The western deposit is on west bank of creek and very small.

No. 39. Tp. 19, range 19, sec. 3. Amount excavated, 150 cu. yds., amount of gravel size, probably small. Areas in sec. 14 and in tp. 18, range 19, sec. 35, sketched from surface indications.

No. 40. Tp. 18, range 18, secs. 30, 19, and tp. 18, range 19, sec. 24. There are small pits in the road and ridges of sand 3 to 4 feet high on both sides of road.

No. 41. Tp. 18, range 19, sec. 12. Owner: Malcolm King, Pilot Butte. Two pits near house. Amount excavated, 15,000 to 20,000 cu. yds. Gravel lies in rounded hill about 60 feet over creek bed to north. Amount in hill uncertain because of occurrence of clay with gravel, but probably large. About half an acre of gravel near creek bottom to north. Two small pits south of farm buildings, covered with heavy overburden to south.

No. 42. Tp. 18, range 18, sec. 7. Owner: city of Regina. About 3,300 cu. yds. excavated, smaller pit across hill to west. (See No. 48.)

No. 43. Tp. 18, range 18, sec. 6. Three pits, largest about 1,200 cu. yds. Three small pits one-half mile south. (See No. 48.)

Nos. 44, 45. Tp. 18, range 18, secs. 7 and 8. Portion in sec. 7, city of Regina, and in sec. 8, G.T.P. Approximate amount excavated at pit 44 is 275,000 cu. yds., at pit 45, 200,000 cu. yds. Depth of pits, 7 to 25 and 5 to 20 feet, respectively, floors in gravel. Spur from G.T.P. into both pits. Used for railway ballast and in Regina for concrete street foundations, buildings, etc. (See No. 48.) Areas south of Boggy creek to north in sec. 8, and in sec. 7 east of main deposit relatively small.

No. 46. Tp. 18, range 18, sec. 8. Owner: G.T.P. Amount excavated, 50,000 cu. yds. Small pits just north and on south slope Boggy creek. (See No. 48.)

No. 47. Tp. 18, range 18, sec. 5. Owners: Whitworth Bros., Regina. Three pits; amount excavated in main pit about 70,000 cu. yds., in east pit 1,500, amount available to northwest, large (See No. 48). Pit, 30 to 45 feet deep in places, sand said to extend 15 feet farther down, water stands at 47 feet from surface. Excavated with small bucket chain and engine, spur from C.P.R. at Pilot Butte. Sold at 60 cents per cu. yd. f.o.b. pit, in large lots. Used in Regina for concrete street foundations, sidewalks, and a number of large buildings.

No. 48. Tp. 18, range 18, secs. 5 and 4. Owner: C.P.R. About 1,000,000 cu. yds. excavated. Small openings south of main pit. Spur from C.P.R. at Pilot Butte. Used for railway ballast and concrete. The deposit ,which includes numbers 42, 43, 44, 45, 46, 47, 48, and 50, see Figure 2, covers approximately 800 acres. The floor of the gravel and sand deposit is not exposed in many places. The gravel is over 45 feet deep in parts of the pits at No. 47 and averages over 12 feet at least near Nos. 44 and 45. There are numerous depressions without outlet; the two largest are shown sketched in Figure 2 and are largely underlain by thick beds of silt and clay (Plate II). The amount of gravel and sand available should be from 10,000,000 to 15,000,000 cu. yds.

No. 49. Tp. 18, range 18, sec. 4. Owner: Pilot Butte Sand Co. Two pits; 55,000 and 65,000 cu. yds. excavated, amount available, large. Material, sand. Spur from C.P.R. at Pilot Butte into pit.

No. 50. Tp. 17, range 18, sec. 32. Owner: Mrs. Betteridge, Pilot Butte. Amount excavated, 20,000 cu. yds. Part of large deposit. Sold for concrete and moulding sand. In sec. 33, 1,240 cu. yds. excavated at southeast end of large area.

No. 51. Tp. 17, range 18, sec. 33. Owner: Morley Billet, Pilot Butte (formerly owned by Pilot Butte Sand Co.). Amount excavated, 180,000 cu. yds., north of village. Sand, only product. Pit of the Interocean Pressed Brick Co. northeast of railway station, about 58,000 cu. yds. excavated. Used in manufacture of sand lime brick. Another sand pit to east. Two small gravel pits on butte to north. Large amount of sand available in this neighbourhood.

No. 52. Tp. 18, range 18, sec. 2. A few cubic yards of sand and gravel in pockets on small boulder clay hills.

No. 53. Tp. 17, range 17, sec. 32. Amount excavated, 8,500 cu. yds. Deposit covers 16 acres 6 to 9 feet deep at road, gravel shows up in little hummocks on plain to south of pit.

No. 54. Tp. 17, range 18, sec. 26; tp. 17, range 17, sec. 30. Five very small, unimportant areas, largest on south line of sec. 30.

No. 55. Tp. 17, range 17, sec. 20. Pit on road allowance, gravel up to 9 feet deep, deposit irregular in depth to southeast. Small area at farmhouse farther southeast.

No. 56. Tp. 17, range 17, sec. 16. Amount excavated, 300 feet in road. To the east the areas are small and sketched from surface showings.

No. 57. Tp. 17, range 17, sec. 2. Small excavation, gravel 5 feet deep at northwest end.

No. 58. Tp. 16, range 17, sec. 35. About 100,000 cu. yds. excavated, probably more than half of whole deposit. Some gravel available east of pit. Used for railway ballast.

No. 59. Tp. 19, range 17, secs. 28 and 22. Two pits in sec. 28, 50 cu. yds. excavated in NW. ¼ sec. 22. Owner: A. Martin, Edenwold. All deposits small. Used for concrete foundations on farm.

No. 60. Tp. 19, range 17, sec. 35. Owner: Jacob Sauer, Edenwold. Amount excavated, 600 cu. yds., amount available, 30,000 to 50,000 cu. yds. Local concrete work.

No. 61. Tp. 19, range 17, sec. 22. Owner: Chas. Winkler, Edenwold. Amount excavated, 350 cu. yds., amount available, 50,000 to 100,000 cu. yds. Local concrete construction. In sec. 23 sand pit at end of narrow ridge. Owner: John Brandt, Edenwold. Used for concrete and building sand. In road allowance there is a small pit and deposit.

No. 62. Tp. 19, range 16, sec. 21. Owners: Northwestern Land Co., Regina. Three very small pits. Very little gravel available.

No. 63. Tp. 19, range 16, secs. 21 and 16. Three or four small pits, several thousand cu. yds. available. Used locally for concrete work.

No. 64. Tp. 19, range 16, sec. 8. Owner: Mr. Sulzer, Avonhurst. About 1,000 cu. yds. excavated in two pits, 10,000 cu. yds. available, 3 to 4 feet of silt overburden over gravel. Used for building sand and concrete. In sec. 14, 200 cu. yards excavated on farm of John Lieb, sold at 15 to 20 cents per load and used locally for concrete work. Area near road east of sec. 14, lies in 20-foot hill and covers 1½ acres.

No. 65. Tp. 19, range 17, sec. 3. Amount excavated, 600 cu. yds., amount available, about 20,000 to 30,000 cu. yds.

No. 66. Tp. 18, range 17, sec. 4. About 5,000 cu. yds. in round hill on farm of Wm. Keil. Sec. 34. Owner: Louis Galonzofskie, Balgonie. Partly on school ground. Amount excavated, 225 cu. yds., amount available, 20,000 cu. yds. Used locally for concrete.

No. 67. Tp. 18, range 17, sec. 27. Owner: province of Saskatchewan. Five pits aggregating 500 cu. yds. Pockets of small extent in ridge 15 to 25 feet high. Extends in sec. 26. Owner: P. Galonzofskie. Used in concrete work on farm buildings of W. Kornelson, work 6 years old, in good shape.

No. 68. Tp. 18, range 16, sec. 30. Owner: K. Schmidt, Balgonie. Amount excavated, 225 cu. yds., used in building farmhouse, small amount left. Small pit to south on farm of A. Rumpel and small ridges extending into sec. 29.

No. 69. Tp. 18, range 16, sec. 33. Owner: L. Galonzofskie, Balgonie. Amount excavated, 450 cu. yds., covers 9 acres in little domes and ridges 12 to 15 feet high. Small deposit south of creek in road.

No. 70. Tp. 18, range 15, sec. 18. Two pits in McLean, 600 cu. yds. and 16,000 cu. yds. Large quantity of rather fine sand available in hill at schoolhouse.

No. 71. Tp. 16, range 17, secs. 1 and 12. Several thousand cu. yds. excavated in pit south of creek. Owner: Rymend Tilschneider, Rastadt. Smaller pits to the north of creek. Mostly sand, said to sell at 30 to 40 cents per load for concrete work in Kronan. Large amount of sand available.

No. 72. Tp. 16, range 16, secs. 7, 8. Excavations small. Covers 95 acres, 15 to 18 feet deep in places. Probably fairly continuous sheet of sand and gravel, with more than 1,000,000 cu. yds. available.

No. 73. Tp. 16, range 16, sec. 24. Amount available, about 100,000 cu. yds. In sec. 23 there are knolls of gravel 5 to 10 feet high over area mapped. Small pit in gravel pocket in sec. 31.

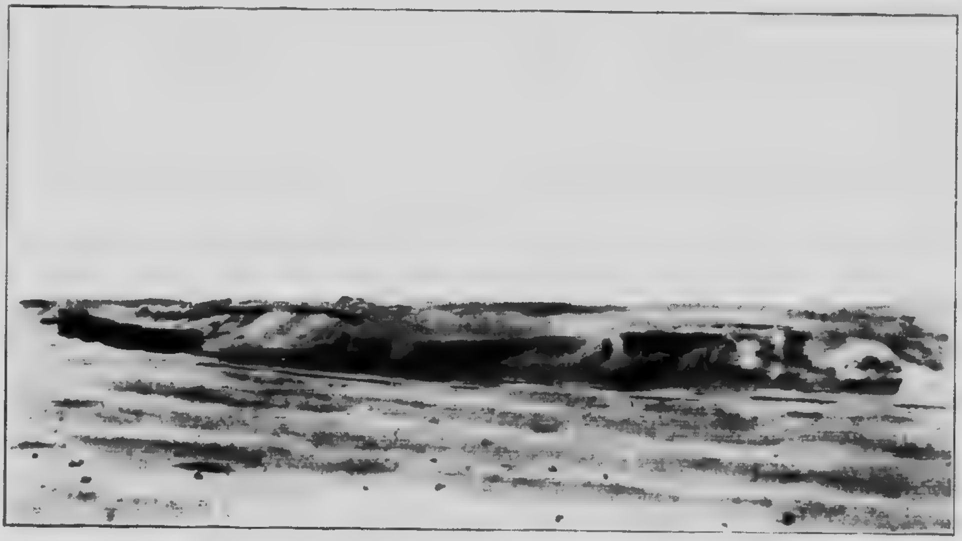
No. 74. Tp. 16, range 16, secs. 12, 13. Small pits in road, extensive areas mapped from surface indications lie in low ridges to west in secs. 13 and 14.

No. 75. Tp. 16, range 16, sec. 3. Owner: J. Obrigewitsch. Small pit, amount available very small. Used in building farmhouse.

No. 76. Tp. 16, range 16, sec. 12. In northwest quarter is a long ridge with surface indications of gravel over it and a volume of about 300,000 cu. yds. Two isolated hills with gravel surfaces in the northeast quarter of section are 18 to 24 feet high and may contain 40,000 cu. yds. above level of plain.

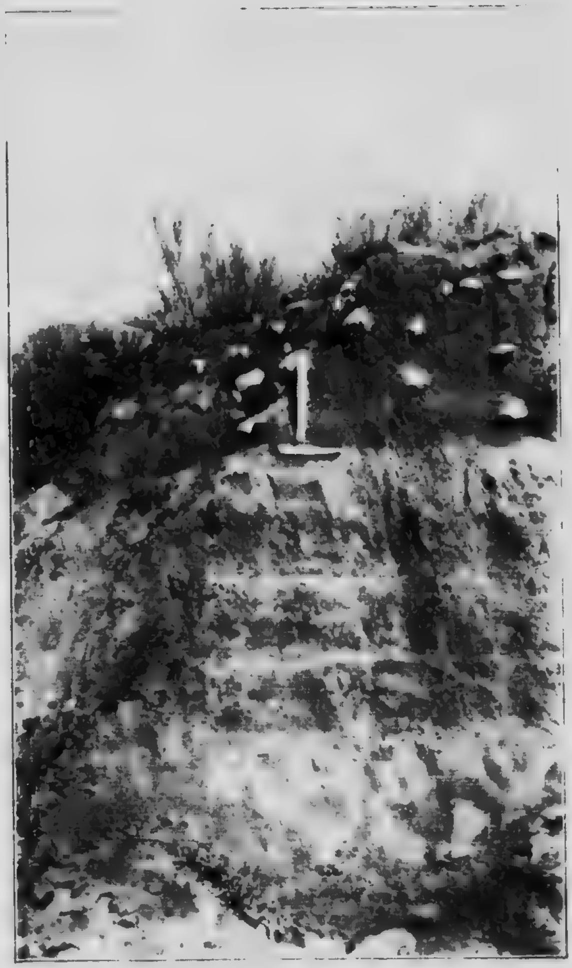
No. 77. Tp. 16, range 16, sec. 12. Two small pits 6 feet deep in road allowance, deposits small.

PLATE I.



North wall of pit No. 45 near Pilot Butte, showing "sag" in gravel deposit. The high wall behind cars on left is of gravel; clay and sand underlie the depression in middle (see Plate II), and silt and brown sand form the wall on right. Farther to right on high ground, just outside the view, the wall is of gravel. (Page 4.)

Plate II.



Closer view of the stratified clay and clayey sands underlying the depressions in gravel deposits. Taken at point near middle of Plate I. Boulder clay on top. (Page 22.)

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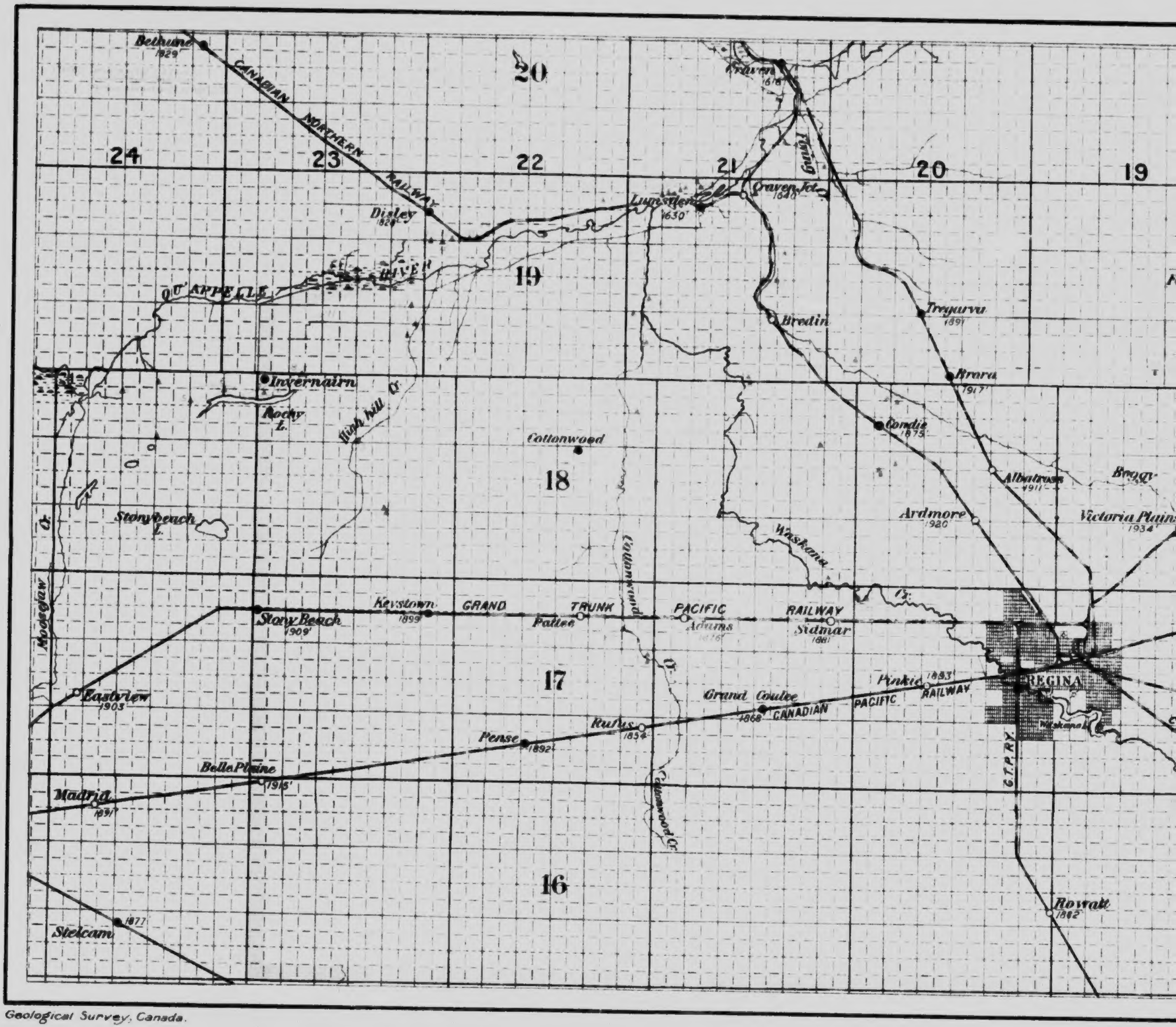

Geological Survey, Canada.

Deposits of gravel in the vicinity of Regina, S

To accompany Memoir by L. Reinecke, 1917.

Scale of Miles

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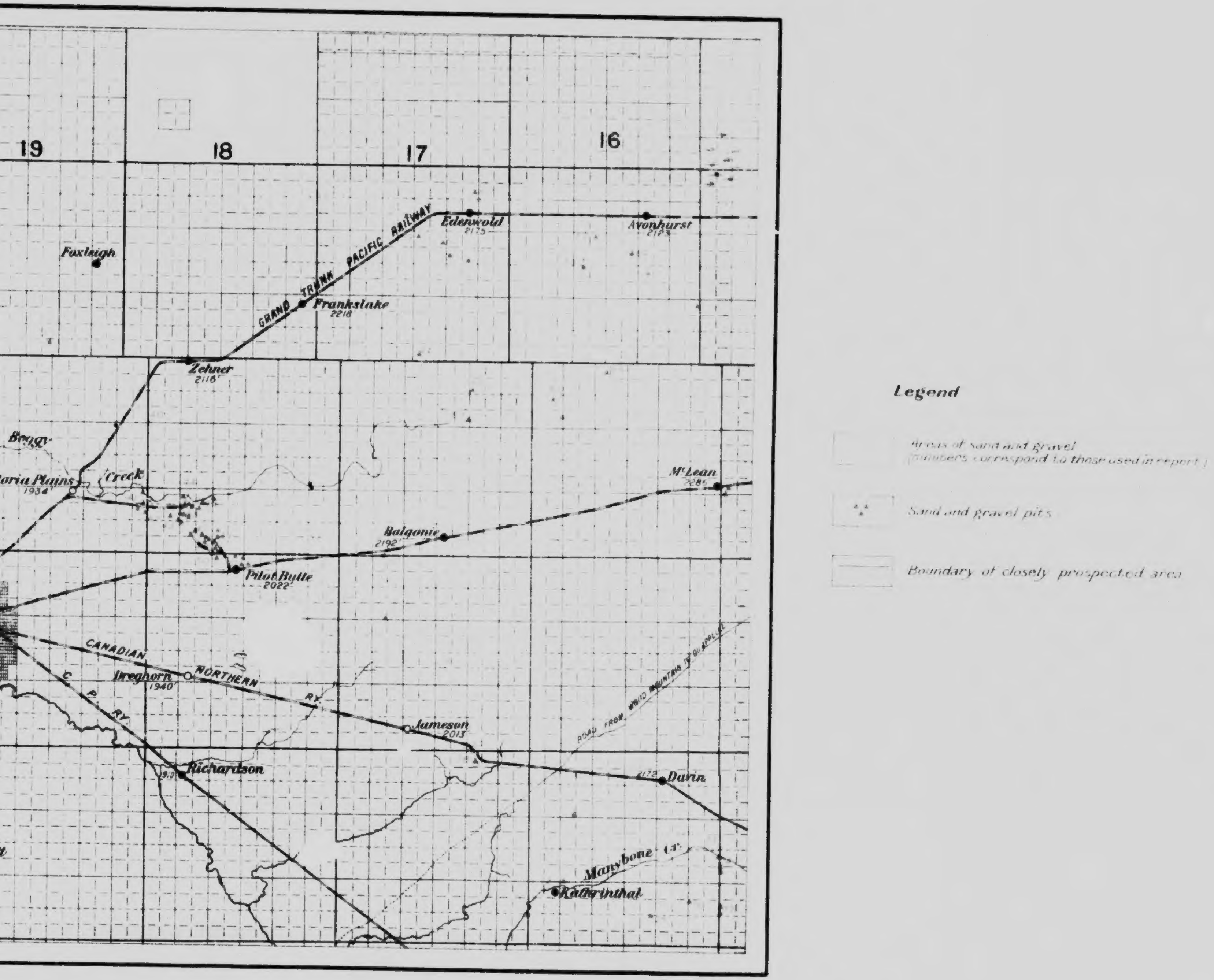

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